NASA TTF-9384

RELATION OF LENGTH OF CARDIAC CYCLE PHASES AND RATE OF PRESSURE CHANGE IN RIGHT AND LEFT VENTRICLES

NASA TTF-9384

V. S. Sal'manovich, I. L. Kosharskaya,
Ye. B. Babskiy

Translation of "Sootnosheniye Dlitel'nosti faz Serdechnogo Tsikla i Skorosti Izmeneniya Davleniya v Pravom i Levom Zheludochkakh". Doklady Akademii Nauk SSSR, Vol. 161, No. 4, pp. 986-988, 1965.

N65 27686 (ACCESSION NUMBER)
(PAGES)
(NASA CR OR TMX OR AD NUMBER)
(THRU) 1
(CODE) 04
(CATEGORY)
FACILITY FORM 602

GPO PRICE $ _____
OTS PRICE(S) $ _____
Hard copy (HC) 1.00
Microfiche (MF) .50

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON D. C. MAY 1965

NASA TTF-9384

RELATION OF LENGTH OF CARDIAC CYCLE PHASES AND RATE OF PRESSURE CHANGE IN RIGHT AND LEFT VENTRICLES

Academician Ye. B. Babskiy (Academy of Sciences, Ukrainian SSR)

V. S. Sal'manovich, I. L. Kosharskaya

ABSTRACT

27684

The purpose of the present study is to study the time structure of the systole in the right and left ventricles and to establish a coordination between the operation of these divisions throughout the cardiac cycle. Experiments were conducted on 50 dogs. It is found that the rate of pressure rise and fall in the left ventricle is several times higher than in the right. Author

One of the little studied aspects of the mechanics of cardiac /986* contraction is the temporal coordination of the operation of the right and left ventricles. It is known that the contraction of both ventricles begins asynchronously (Ref. 1, 4), and the duration of the

---

* Note: Numbers in the margin indicate pagination in the original foreign text.

phase of isometric tension in the right ventricle is shorter than in the left (Ref. 2). The temporal relationships of all systolic phases in these sections of the heart have been inadequately investigated, nor has sufficient study been devoted to an index of cardiac dynamics such as the rate of change of intraventricular pressure, the determination of which permits an immediate judgment of the change in contractile capacity of the myocardium throughout the cardiac cycle.

Of particular importance to an understanding of cardiac dynamics is a comparative analysis of the rates of pressure rise and fall in both ventricles.

Therefore, the aim of the present paper has been to study the time structure of the systole in the right and left ventricles and to establish a coordination between the well-defined events in the operation of these divisions throughout the cardiac cycle. In addition to this, the rate of intraventricular pressure change has been studied in order to give a comparative characterization of the intensity of the contractile process in the right and left ventricles.

Closed-chest experiments were conducted on 50 dogs under morphine-urethan narcosis. The time structure of the contraction cycle of the right and left ventricles was determined by analyzing the systolic phases of these two divisions. For this purpose, the pressure in the right or left ventricle was synchronously recorded and in the pulmonary artery or aorta, respectively, while an electrocardiogram in the II standard lead was also recorded. Catheters were introduced into the

cardiac cavities and vessels via the carotid arteries or the external jugular veins. A two-channel electromanometer recording optically on a three-channel electrocardiograph was used to register pressure. The rate of paper travel was 50 or 100 mm/sec. In twenty experiments, the rate of pressure change at various systolic phases of the right (ten experiments) and of the left (ten experiments) ventricle was determined by graphic differentiation.

The results of analyzing the systolic phases of both ventricles are correlated in Table 1. It is evident from this table that, for an identical range of rhythms, the length of asynchronous contraction of the left ventricle is shorter than that of the right. The period of this dissociation averages about 0.002 sec. Since we knew the very slight degree of asynchronism between the beginning of pressure rise in both ventricles was covered by the degree of error of the method, no essential significance could be attributed to this difference. Therefore, we may in practice assume that pressure rise in both ventricles begins simultaneously. This conclusion agrees with the findings of other authors (Ref. 3), who synchronously recorded pressure and its rate of change in both ventricles. The measurement of rate is a more reliable test to determine the initial /987 moment of pressure rise in the ventricle, since the rate curves begin to be much steeper than the pressure curves and make possible a significantly more accurate determination of the beginning of pressure rise in the heart chambers.

The average duration of isometric contraction in the right ventricle

TABLE 1

NORMS OF SYSTOLIC PHASE DURATION (IN SECONDS) OF RIGHT AND LEFT VENTRICLE IN NARCOTIZED DOGS.

	Asynchronous Contraction	Isometric Contraction	Expulsion	Rapid Expulsion	Slow Expulsion	Mechanical System	Contraction Frequency Per Min
			Left Ventricle (n=30)				
Fluctuation Limits	0.03-0.04	0.03-0.05	0.14-0.20	0.08-0.12	0.05-0.08	0.17-0.24	60-150
M	0.038	0.038	0.162	0.102	0.06	0.06	116
$\pm\sigma$	0.002	0.006	0.022	0.013	0.009	0.022	
			Right Ventricle (n=20)				
Fluctuation Limits	0.04	0.02-0.04	0.14-0.20	0.06-0.08	0.08-0.10	0.16-0.23	60-150
M	0.04	0.028	0.162	0.067	0.094	0.19	118
$\pm\sigma$	-	0.003	0.021	0.011	0.010	0.024	
p	< 0.01	< 0.001		< 0.001	< 0.001	< 0.02	

is 0.01 sec shorter than in the left. This result is apparently associated with the large difference between the final diastolic pressure in the pulmonary artery and aorta, against which the ventricles are working.

Since the period of isometric contraction is shorter in the right ventricle than in the left, it is natural that expulsion of blood by the right side of the heart also begins before the expulsion by the left. The difference is 0.01 sec, on the average. The duration of expulsion, however, is identical for both ventricles.

Analysis of the phase time-structure of blood expulsion by both ventricles revealed regular differences. Duration of rapid expulsion proved to be 0.035 sec shorter in the right ventricle than in the left. The reverse relation held true in regard to duration of slow expulsion. Comparison of the data in the table also shows that the mechanical systole of the left ventricle lasts somewhat longer than does that of the right. This difference is entirely determined by the difference in the duration of isometric contraction phases of both ventricles.

Along with the time relations of right and left ventricle operation, our work also investigated the rate of pressure change in these divisions at different systolic phases.

Figure 1 gives the typical curve for rate of pressure change at different phases of the cycle of the left and right ventricles. It is evident from the figure that the rate of pressure change in the /988 isometric contraction phase rises stepwise and attains a high value.

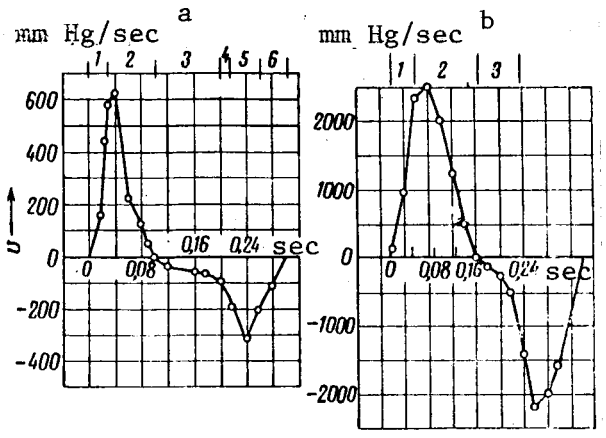

Figure 1

Rate of Pressure Change in Different Phases of Contraction Cycle of (a) Right and (b) Left Ventricle of Heart. (1)-Isometric Contraction; (2)-Rapid Expulsion; (3)-Slow Expulsion; (4)-Protodiastole; (5)-Isometric Relaxation; (6)-Rapid Inflation.

It then further increases somewhat, becoming maximum at the initial period of rapid expulsion. In the phase of slow expulsion, the rate of pressure change drops abruptly and acquires a negative value. The rate of intraventricular pressure drop reaches its highest value in the period of isometric relaxation. It is interesting to note that the rate of pressure drop in the phase of isometric relaxation is approximately equal to the rate of pressure rise in the phase of isometric contraction. Thereafter, the rate of pressure drop decreases and by the end of the period of rapid inflation has adopted a zero value.

Table 2 lists the average values of the pressure change rate during systole of the right and left ventricles.

TABLE 2

AVERAGE VALUES OF PRESSURE CHANGE RATE IN LEFT AND RIGHT VENTRICLES IN DIFFERENT PHASES OF CARDIAC CYCLE (IN mm Hg/sec).

	(a)	(b) Изометрич. сокращение (конечная скорость)	(b) Быстрое изгнание (c) начальн. скорость	(b) Быстрое изгнание (d) максим. скорость	(e) Медленное изгнание (конечная скорость)	(f) Изометрич. расслабление (максим. скорость)	(g) Частота сокращений сердца, мин.
(h)	Левый желудочек (n=10)	2300	2300	3000	—710	—2190	121
(i)	Правый желудочек (n=10)	416	416	540	—139	—424	126

(a)-Isometric Contraction (final rate); (b)-Rapid Expulsion; (c)-Initial Rate; (d)-Maximum Rate; (e)-Slow Expulsion (final rate); (f)-Isometric Relaxation (maximum rate); (g)-Cardiac Contraction Frequency Per Min; (h)-Left Ventricle; (i)-Right Ventricle.

The average final rate of pressure rise in the phase of isometric contraction is 5 times higher in the left ventricle than in the right. By approximately the same factor, the maximum rate of rapid expulsion from the left ventricle exceeds that from the right. The phase of slow expulsion of blood from the left ventricle is also characterized by a greater rate of pressure drop. And, finally, the maximum rates of intraventricular pressure drop during isometric relaxation of the right and left ventricles display an almost five-fold difference.

The rate of pressure rise and fall in the left ventricle is therefore several times higher than in the right. It is at present very difficult to detect all the factors determining this difference in rates of pressure change between the right and left ventricles. One of these factors may be assumed to be the difference between the two ventricles in muscular mass, which determines the strength of contraction.

The above data on the rate of pressure change in various phases

of the cycle were derived from dogs with chests unopened - opening the chest is, as a rule, attended by a substantial (approximately three-fold) decrease in pressure change rate.

Institute of Normal and
Pathological Physiology,
Academy of Medical Sciences,
USSR

Received 14 August 1964.

REFERENCES

1. Karpman, V. L. and Savel'yev, V. S. Fiziologicheskiy Zhurnal SSSR, 46, No. 3, 310, 1960.

2. Coblentz, B., Harvey, R. M., et al. British Heart Journal, 11, 1, 1949.

3. Coghlan, C., Prieto, G., and Harrison, T. R. American Heart Journal, 62, 1, 65, 1965.

4. Katz, L. N. American Journal of Physiology, 72, 655, 1925.

Scientific Translation Service
1144 Descanso Drive
La Canada, California